U. S. DEPARTMENT OF COMMERCE
HARRY L. HOPKINS, Secretary
NATIONAL BUREAU OF STANDARDS
LYMAN J. BRIGGS, Director

INTERCHANGEABLE GROUND-GLASS JOINTS, STOPCOCKS, AND STOPPERS

(FOURTH EDITION)

COMMERCIAL STANDARD CS21-39

[Supersedes CS21-36]

Effective Date, February 15, 1939

A RECORDED STANDARD OF THE INDUSTRY

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PROMULGATION

of

COMMERCIAL STANDARD CS21-39

for

INTERCHANGEABLE GROUND-GLASS JOINTS, STOPCOCKS, AND STOPPERS

(Fourth Edition)

On December 19, 1929, a joint conference of representative manufacturers, distributors, and users of laboratory glassware adopted a commercial standard for interchangeable ground-glass joints which was accepted by the industry and promulgated as Commercial Standard CS21-30. Following the successful use of this standard, the standing committee recommended its extension to include interchangeable ground-glass stopcocks and stoppers, in a suitable revision which was accepted and promulgated as Commercial Standard CS21-34. Increasing use of interchangeable joints developed a demand for additional sizes and lengths which resulted in a second revision, accepted and promulgated as CS21-36. Subsequently, as a further extension to include short length joints, primarily for weighing bottle covers, the standing committee recommended a third revision as shown herein, which the industry has accepted and approved for promulgation by the United States Department of Commerce through the National Bureau of Standards.

The revised standard is effective for new production beginning February 15, 1939.

Promulgation recommended

I. J. Fairchild,
Chief, Division of Trade Standards.

Promulgated.

Lyman J. Briggs,
Director, National Bureau of Standards.

Promulgation approved.

Harry L. Hopkins,
Secretary of Commerce.

INTERCHANGEABLE GROUND-GLASS JOINTS, STOPCOCKS, AND STOPPERS

(Fourth Edition)

COMMERCIAL STANDARDS CS21–39

PURPOSE

1. The purpose of this commercial standard is to provide standard dimensional requirements for obtaining, within practical limits, interchangeability in ground-glass joints, stopcocks, and stoppers for ordinary laboratory and industrial work. It covers dimensional interchangeability only and does not involve physical or chemical characteristics of glass.

SCOPE

2. This standard covers (1) interchangeable ground-glass joints for laboratory and industrial glassware in sizes from 5 to 71 mm approximate diameter at the large end of ground zone for full-length grindings; from 5 to 40 mm for medium-length grindings; and from 10 to 71 mm for short-length grindings; (2) interchangeable straight-bore, ground-glass stopcocks from 1- to 10-mm bore; (3) interchangeable ground-glass stoppers from 9 to 38 mm approximate diameter at the large end of ground zone for volumetric flasks, stoppered Erlenmeyer flasks, stoppered cylinders, separatory funnels, and iodine determination flasks; and (4) interchangeable ground-glass stoppers from 14 to 45 mm approximate diameter at the large end of ground zone for reagent bottles.

GENERAL REQUIREMENTS

3. *Taper.*—All commercial standard interchangeable ground-glass joints, stopcocks, and stoppers shall have a taper of 1 ±0.006 mm/cm of length on diameter (1 to 10).

4. *Master gages.*—All commercial standard interchangeable ground-glass joints, stopcocks, and stoppers shall be made from working tools that have been checked with standard gages certified by the National Bureau of Standards.

5. *Master gage material and taper.*—All master gages shall be made of tool steel, hardened and ground. Taper shall be 1 ±0.0006 mm/cm of length on diameter.

DETAIL REQUIREMENTS

A. INTERCHANGEABLE GROUND-GLASS JOINTS

TABLE 1.—*Standard dimensions for full-length interchangeable ground-glass joint*

Standard joint size number (designation) [a]	Approximate diameter at small end *A*	Approximate length of ground zone *B*	Computed diameter at large end of ground zone (gaging point) *C*
	mm	*mm*	*mm*
5/20	3	20	5.0
7/25	5	25	7.5
10/30	7	30	10.0
12/30	9	30	12.0
14/35	11	35	14.5
19/38	15	38	18.8
24/40	20	40	24.0
29/42	25	42	29.2
34/45	30	45	34.5
40/50	35	50	40.0
45/50	40	50	45.0
50/50	45	50	50.0
55/50	50	50	55.0
60/50	55	50	60.0
71/60	65	60	71.0

[a] The first two editions of this standard, CS21-30 and CS21-34, used the diameter of the small end of the ground zone as the size designation. This edition, and also the third (CS21-36), use the approximate diameter at the large end and a length designation to provide for indication of different lengths. Users of apparatus with interchangeable ground-glass joints numbered according to CS21-30 and CS21-34 may order replacement parts by specifying the size number etched on the apparatus; the absence of a length designation will inform the manufacturer or distributor that the number refers to the old series. If the size given includes the length designation it will be clear that the number belongs to the new series. Medium- and short-length joints covered by tables 2 and 3 have diameters at the large end of the ground zone equal to the large diameter of the corresponding full-length joint in table 1.

TABLE 2.—*Standard dimensions for medium-length interchangeable ground-glass joints*

Standard joint size number (designation)	Approximate diameter at small end *A*	Approximate length of ground zone *B*	Computed diameter at large end of ground zone (gaging point) *C*
	mm	*mm*	*mm*
5/12	3.8	12	5.0
7/15	6.0	15	7.5
10/18	8.2	18	10.0
12/18	10.2	18	12.0
14/20	12.5	20	14.5
19/22	16.6	22	18.8
24/25	21.5	25	24.0
29/26	26.6	26	29.2
34/28	31.7	28	34.5
40/35	36.5	35	40.0

TABLE 3.—*Standard dimensions for short-length interchangeable ground-glass joints*

Standard joint size number (designation)	Approximate diameter at small end *A*	Approximate length of ground zone *B*	Computed diameter at large end of ground zone (gaging point) *C*
	mm	*mm*	*mm*
10/10	9.0	10	10.0
12/10	11.0	10	12.0
14/10	13.5	10	14.5
19/10	17.8	10	18.8
24/12	22.8	12	24.0
29/12	28.0	12	29.2
34/12	33.3	12	34.5
40/12	38.8	12	40.0
45/12	43.8	12	45.0
50/12	48.8	12	50.0
55/12	53.8	12	55.0
60/12	58.8	12	60.0
71/15	69.5	15	71.0

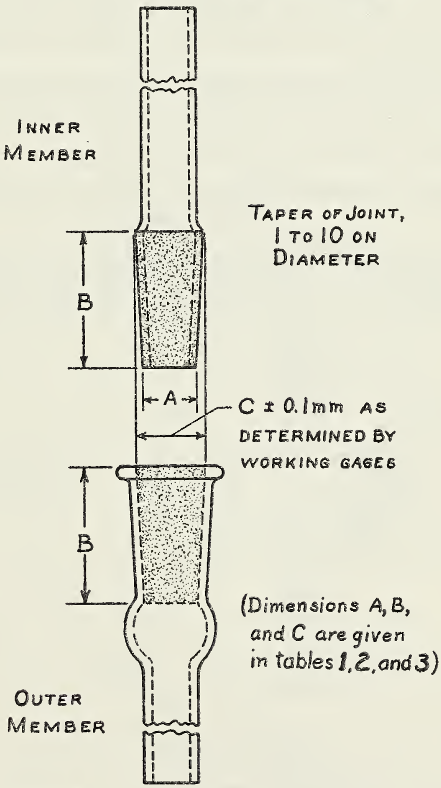


FIGURE 1.—*Interchangeable ground-glass joint.*

6. *Tube diameter and length.*—The outside diameter of the tube shall correspond approximately to the outside diameter of the small end of the inner member of the ground joint, dimension *A*, table 1. Total length of assembled joints shall be approximately 30.5 cm (12 in.).

MASTER GAGES FOR INTERCHANGEABLE GROUND-GLASS JOINTS

7a. *Plug gage.*—The length of the taper portion of plug gage shall be the approximate length of the ground zone as given in table 1, plus not less than 12 mm nor more than 14 mm. New gages shall have a diameter at a point 10 mm from the large end of ground portion corresponding to the computed diameter at the large end of ground zone ±0.005 mm. This point shall be known as the gaging point. Small end of gage and shoulder at large end shall be ground perpendicular to axis. Plug gage shall be provided with a suitable handle.

7b. *Ring gage.*—Length of ring shall equal approximate length of ground zone as given in table 1 within ±0.1 mm. Outside diameter of ring shall be approximately twice the diameter at small end of ground zone but not less than 25 mm. Both ends of rings shall be ground perpendicular to the axis.

7c. *Fit of mating gages.*—When ring is fitted hand-tight on its mating plug, large end of ring shall come within ±0.15 mm of the gaging point on plug. Finish of ground surfaces on both plug and ring shall be such, and taper shall match sufficiently, that 75 percent of the ground surface of the ring shall show contact with its mating plug when wrung together with surface of plug covered with a light coating of prussian blue in oil.

7d. *Fit of product in working gages.*—The product (both inner and outer members) shall fit in the corresponding working gages within ±1.0 mm along the axis from the gaging point.

B. INTERCHANGEABLE STRAIGHT-BORE GROUND-GLASS STOPCOCKS

8. Interchangeable ground-glass stopcocks are not intended for vacuum apparatus or for use with light liquids. When it becomes necessary to replace a plug of an interchangeable stopcock which, by

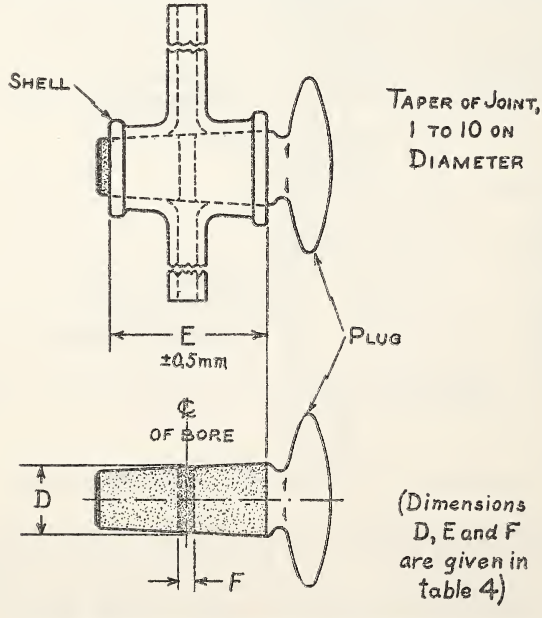


Figure 2.—*Interchangeable ground-glass stopcock.*

constant abrasion, has become worn so that the shell is enlarged while the plug is diminished in size or otherwise physically or chemically acted upon, then interchangeable stopcock plugs cannot be expected to fit properly in the shell.

TABLE 4.—*Standard dimensions for interchangeable straight-bore ground-glass stopcocks*

Standard stopcock number	Diameter of plug at center line of bore *D*	Length of shell ±0.5 mm *E*	Diameter of bore hole in plug *F*
	mm	*mm*	*mm*
1	12	30	1
1½	12	30	1½
2	12	30	2
3	17	40	3
4	17	40	4
5	20	44	5
6	20	44	6
8	25	52	8
10	35	56	10

9. *Shell.*—The length of shell (product) shall be as given in table 4, ±0.5 mm.

MASTER GAGES FOR INTERCHANGEABLE GROUND-GLASS STOPCOCKS

10a. *Plug gage.*—The length of taper portion of the plug gage shall be the length of the shell as given in table 4 plus not less than 12 mm nor more than 14 mm. Plug shall have a circumferential reference line (gaging point) approximately 0.1 mm (0.075 to 0.150 mm) wide located on new gages at a point one-half the length of the shell plus 10 to 11.5 mm from the large end of the taper portion. The diameter at center of reference line (gaging point) shall equal diameter of plug at center line of bore, table 4, within ±0.003 mm. Plug shall have two short axial lines 180° (±0.5°) apart intersecting reference line (gaging point) for checking location of bore hole. Plug gage shall also have two circumferential reference lines near the large end, located at points ($\frac{1}{2}E-0.5$ mm) and ($\frac{1}{2}E+0.5$ mm), respectively, from the gaging point. The tolerance on location of these lines shall be plus or minus 0.05 mm. The small and large ends of the taper portion of the gage shall be ground perpendicular to the axis, and each plug gage shall be provided with a suitable handle.

10b. *Ring gage.*—The length of the ring gage shall equal the length of the shell, table 4, plus 0.2 mm, minus 0.0 mm. Ring gage shall have a central milled recess or window. Width of recess measured parallel with the axis shall be approximately one-fourth the length of the shell, and the width of the opening at the inner surface of ring, measured perpendicular to axis, shall not exceed one-fourth the length of the shell. Reference line in recess shall be approximately 0.1 mm (0.075 to 0.150 mm) wide and placed midway between ends of ring gage within ±0.1 mm on new gages.

10c. The outside diameter of rings shall be approximately twice the diameter at center line of bore, table 4, but not less than 25 mm. The ends of the ring gage shall be ground perpendicular to the axis.

10d. *Fit of mating gages.*—When a ring is fitted hand-tight on its

mating plug, the middle of the reference lines of each member shall not be apart more than 0.15 mm. The finish of the ground surfaces on both plug and ring shall be such, and tapers shall match sufficiently, that 75 percent of the ground surface of the ring shall show contact with its mating plug when wrung together with the surface of the plug covered with a light coating of prussian blue in oil. Full contact shall be shown at the reference line (gaging point) under these conditions.

10e. *Fit of product in working gages.*—The product (inner member) shall fit in the ring gage so that the bore of the plug shall center on the reference line of the ring gage as near as can be judged by the eye. The shell shall fit on the plug gage so that reference line (gaging point) is ½ $E \pm 0.5$ mm from the large end of the shell. At the center line of bore, the grinding of both plug and shell shall show full contact with the respective gages, and shall be free from any striations. The small end of ground zone of stopcock plug shall extend beyond end of ring gage not less than 2 mm.

C. INTERCHANGEABLE GROUND-GLASS FLASK STOPPERS

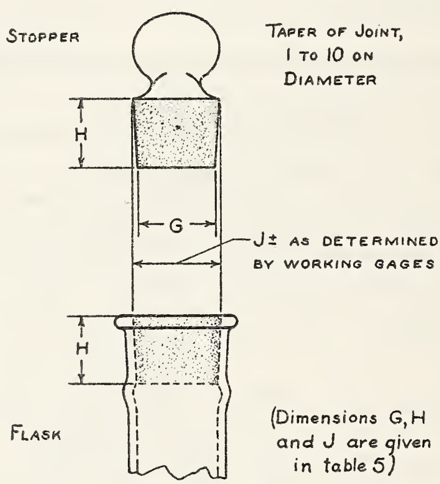


FIGURE 3.—*Interchangeable ground-glass flask stopper.*

TABLE 5.—*Standard dimensions for interchangeable ground-glass flask stoppers*

Standard flask stopper number	Approximate diameter at small end *G*	Length of ground zone *H*	Computed diameter at large end of ground zone (gaging point) *J*
	mm	*mm*	*mm*
9	8	14.0 ±1.0	9.4
13	12	14.0 ±1.0	13.4
16	15	15.0 ±1.0	16.5
19	18	17.0 ±1.0	19.7
22	20	20.5 ±1.5	22.05
27	25	21.5 ±1.5	27.15
32	30	21.5 ±1.5	32.15
38	35	30.0 ±2.0	38.0

MASTER GAGES FOR INTERCHANGEABLE GROUND-GLASS FLASK STOPPERS

11a. *Plug gage.*—The length of the taper portion of plug gage shall be the maximum length of the ground zone as given in table 5, plus not less than 12 mm nor more than 14 mm. New gages shall have a diameter at a point 10 mm from the large end of ground portion corresponding to the computed diameter at the large end of ground zone ±0.005 mm. This point shall be known as the gaging point. Small end of gage and shoulder at large end shall be ground perpendicular to axis. Plug gage shall be provided with a suitable handle.

11b. *Ring gage.*—Length of ring shall equal maximum length of ground zone as given in table 5 within ±0.1 mm. Outside diameter of ring shall be approximately twice the diameter at the small end of the ground zone but not less than 25 mm. Both ends of rings shall be ground perpendicular to the axis.

11c. *Fit of mating gages.*—When ring is fitted hand-tight on its mating plug, large end of ring shall come within ±0.15 mm of the gaging point on plug. Finish of ground surfaces on both plug and ring shall be such, and tapers shall match sufficiently, that 75 percent of the ground surface of the ring shall show contact with its mating plug when wrung together with surface of plug covered with a light coating of prussian blue in oil.

11d. *Fit of product in working gages.*—The large end of stopper shall come flush with large end of ring gage within ±0.5 mm along the axis for stoppers Nos. 9 to 19, inclusive; and within ±1.0 mm along the axis for stoppers Nos. 22 to 38, inclusive.

11e. Plug gage shall enter flask so that gaging point on plug shall be at least 0.5 mm and not over 1.5 mm above extreme top surface of flask for stoppers Nos. 9 to 19, inclusive; and at least 1.0 mm and not over 3.0 mm for stoppers Nos. 22 to 38, inclusive.

D. INTERCHANGEABLE GROUND-GLASS REAGENT BOTTLE STOPPERS

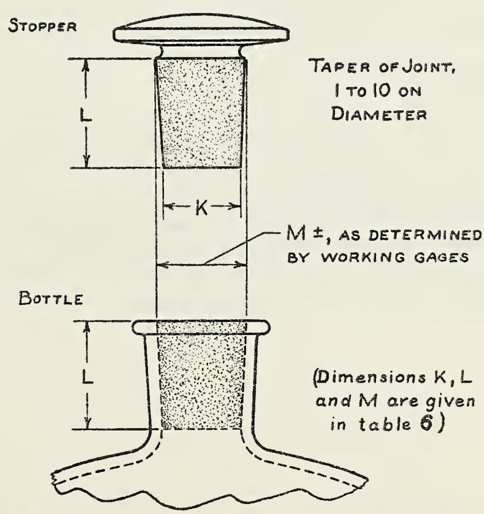


Figure 4.—*Interchangeable ground-glass reagent bottle stopper.*

TABLE 6.—*Standard dimensions for interchangeable ground-glass reagent bottle stoppers*

Standard bottle stopper number	Approximate diameter at small end *K*	Length of ground zone *L*	Computed diameter at large end (gaging point) *M*
	mm	*mm*	*mm*
14	12.5	20 ±1.5	14.5
19	16.6	22 ±1.5	18.8
24	21.0	30 ±2.0	24.0
29	25.5	35 ±2.0	29.0
34	30.5	40 ±2.0	34.5
45	40.3	47 ±2.0	45.0

MASTER GAGES FOR INTERCHANGEABLE GROUND-GLASS REAGENT BOTTLE STOPPERS

12a. *Plug gage.*—The length of the taper portion of plug gage shall be the maximum length of the ground zone as given in table 6, plus not less than 12 mm nor more than 14 mm. New gages shall have a diameter at a point 10 mm from the large end of ground portion corresponding to the computed diameter at the large end of ground zone ±0.005 mm. This point shall be known as the gaging point. Small end of gage and shoulder at large end shall be ground perpendicular to axis. Plug gage shall be provided with a suitable handle.

12b. *Ring gage.*—Length of ring shall equal maximum length of ground zone as given in table 6 within ±0.1 mm. Outside diameter of ring shall be approximately twice the diameter at the small end of the ground zone but not less than 25 mm. Both ends of rings shall be ground perpendicular to the axis.

12c. *Fit of mating gages.*—When ring is fitted hand-tight on its mating plug, large end of ring shall come within ±0.15 mm of the gaging point on plug. Finish of ground surfaces on both plug and ring shall be such, and tapers shall match sufficiently, that 75 percent of the ground surface of the ring shall show contact with its mating plug when wrung together with surface of plug covered with a light coating of prussian blue in oil.

12d. *Fit of product in working gages.*—The large end of stopper shall come flush with large end of ring gage within ±0.5 mm along the axis for stoppers Nos. 14 and 19 and within ±1.0 mm along the axis for stoppers Nos. 24 to 45, inclusive.

12e. Plug gage shall enter bottle so that gaging point on plug shall be at least 0.5 mm and not over 1.5 mm above extreme top surface of bottle for stoppers Nos. 14 and 19; and at least 1.0 mm and not over 3.0 mm for stoppers Nos. 24 to 45, inclusive.

MARKING

13. Interchangeable ground-glass joints, stopcocks, and stoppers conforming to this commercial standard shall be marked on both members with this symbol———> indicating standard taper, followed by the size designation and the trade-mark of manufacturer or distributor. This symbol is the manufacturer's assurance to purchasers that the item identified by the symbol is a standard interchangeable size and type described in this pamphlet, and is manufactured within the tolerances permitted by this commercial standard. It shall not be used on joints, stopcocks, or stoppers, nor in the advertising description of joints, stopcocks, or stoppers of any size or type other than those described in this commercial standard.

14. Joints and stoppers covered by tables 1, 2, 3, 5, and 6 are shown diagrammatically in figure 5, pages 12 and 13, grouped for ready comparison.

EFFECTIVE DATE

The standard is effective for new production from February 15, 1939.

STANDING COMMITTEE

The following comprises the membership of the standing committee which is to review, prior to circulation for acceptance, revisions proposed to keep the standard abreast of progress. Comment concerning the standard and suggestions for revision may be addressed to any member of the committee or to the Division of Trade Standards, National Bureau of Standards, which acts as secretary for the committee.

J. Edward Patterson (chairman), Arthur H. Thomas Co., 230 South Seventh Street, Philadelphia, Pa.
Walter R. Eimer, Eimer & Amend, Third Avenue and Eighteenth Street., New York, N. Y.
Frederick Kraissl, Corning Glass Works, 718 Fifth Avenue, New York, N. Y.
William Geyer, Scientific Glass Apparatus Co., 49 Ackerman Street, Bloomfield, N. J.
James J. Moran, Kimble Glass Co., Vineland, N. J.
Edw. A. Krebs, Eck & Krebs, 131 West Twenty-fourth Street, New York, N. Y.
Kenneth B. Andrus, Corning Glass Works, Corning, N. Y.
Leonardo Testa, Fixed Nitrogen Testing Laboratory, U. S. Dept. of Agriculture, Friendship Post Office, Washington, D. C.
Prof. Edward H. Cox, Swarthmore College, Swarthmore, Pa.
W. D. Collins, American Chemical Society, c/o U. S. Geological Survey, Washington, D. C.
D. R. Miller, National Bureau of Standards, Washington, D. C.

HISTORY OF PROJECT

Pursuant to a request from manufacturers and distributors of laboratory glassware, a general conference of manufacturers, distributors, and users of interchangeable ground-glass joints was held on December 17, 1929, at the National Bureau of Standards, Washington, D. C., to consider the establishment of commercial standard tapers and diameters on the basis of a preliminary draft submitted by a committee of manufacturers and dealers. The conference adopted the proposed standard unanimously, after making certain minor adjustments, and recommended it for acceptance by the industry. After acceptance had been formally given, the standard was promulgated and issued in printed form as Commercial Standard CS21–30, which became effective August 1, 1930.

FIRST REVISION

The standing committee, as a result of conferences on May 25 and July 20, 1933, recommended the extension of the commercial standard to include 3, 9, and 65 mm sizes of interchangeable ground-glass joints; 5 sizes of interchangeable straight-bore, ground-glass stopcocks; 8 sizes of interchangeable ground-glass flask stoppers; and 6 sizes of interchangeable ground-glass reagent bottle stoppers. The proposed revision was circulated to the industry on January 5, 1934, for written acceptance, with the result that the revised standard was accepted and authorized by the industry for publication as Commerical Standard CS21–34, effective September 1, 1934.

SECOND REVISION

In response to a demand for additional sizes and lengths of grindings, the standing committee met on February 11, 1936, and adopted a second revision, which was circulated to the industry for acceptance on March 18, 1936. Success of the revision was announced May 15, 1936, and it was published as CS21–36, effective from that date.

THIRD REVISION

On November 2, 1938, the standing committee adopted the third revision to provide a series of short-length joints for use primarily on weighing bottles with interchangeable covers. This revision was circulated to the industry for acceptance on December 9, 1938, and the success of the revision was announced February 1, 1939, to be effective February 15, 1939.

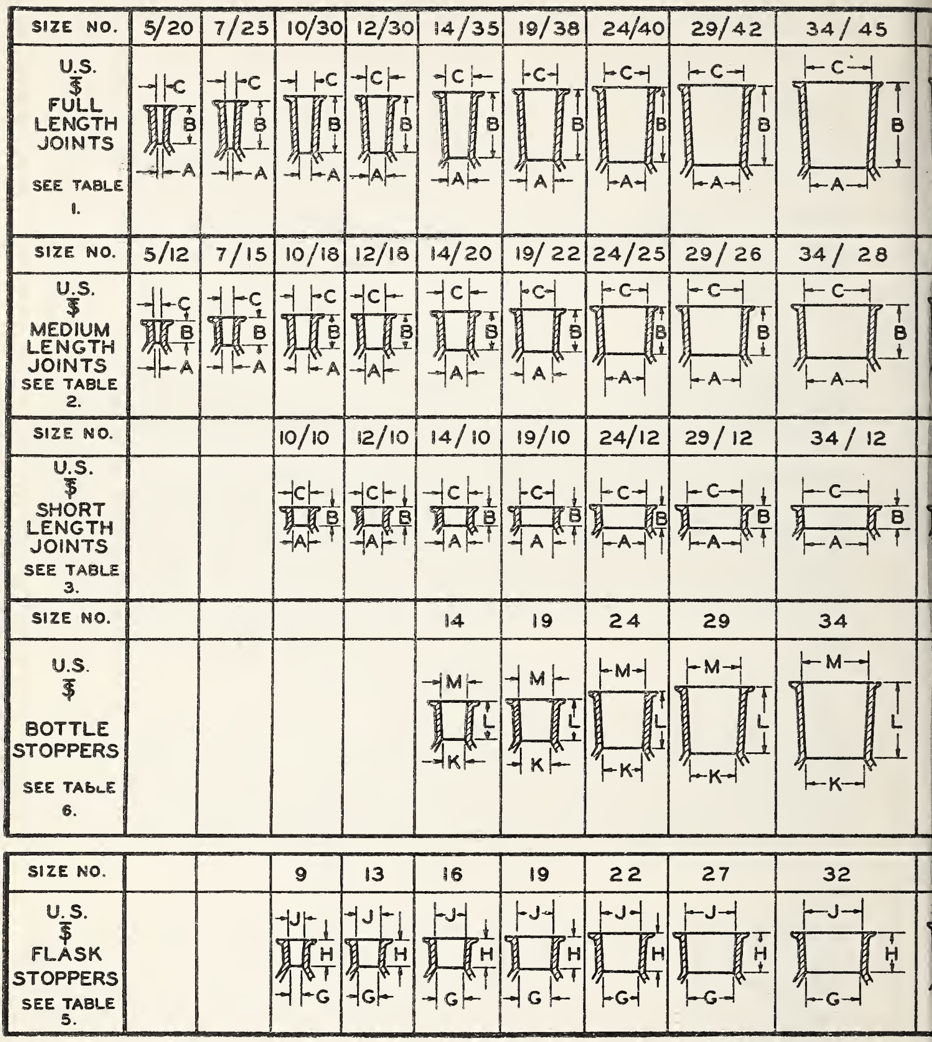
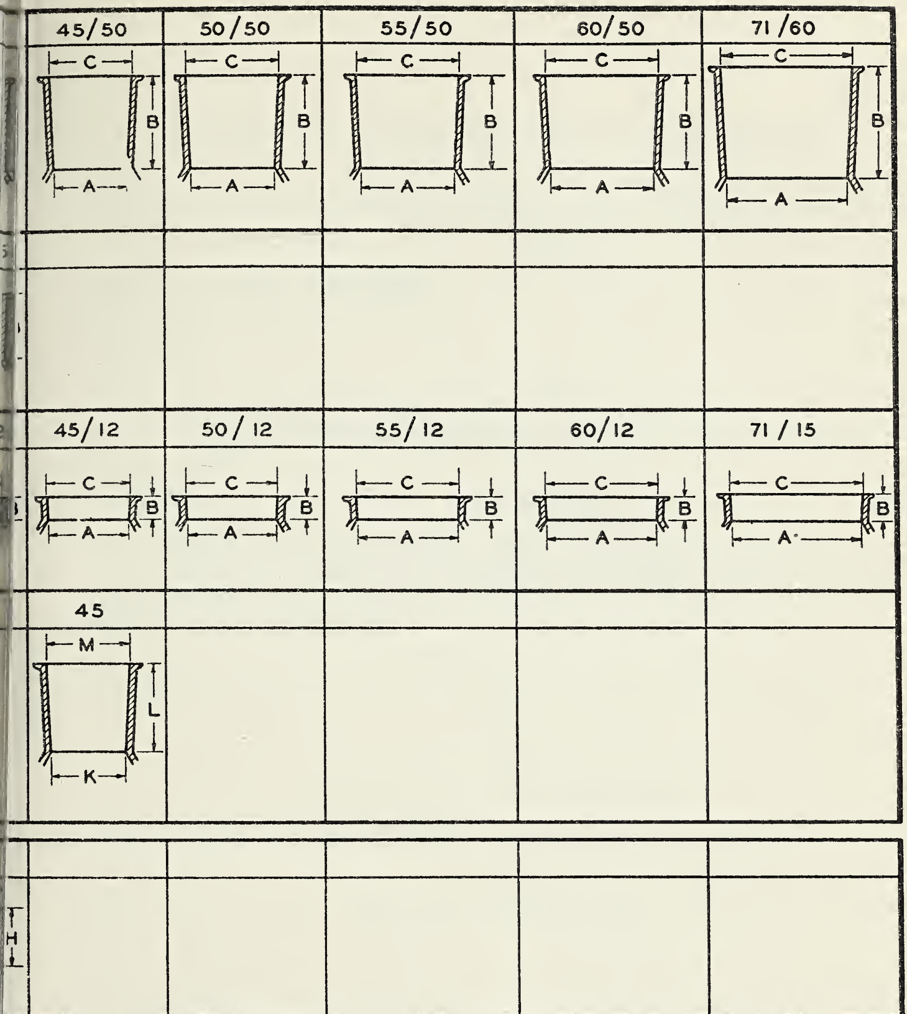


FIGURE 5. COMPARATIVE SIZES OF I

SCA

DIMENSIONS A,B,... L,M, ARE GIVEN IN TABLES
DIAMETER IN MILLIMETERS OF LARGE END OF



ANGEABLE JOINTS AND STOPPERS

SIZE

ND 6. SIZE NUMBERS INDICATE APPROXIMATE
RS, AND LARGE END / LENGTH OF JOINTS

Cut on this line

ACCEPTANCE OF COMMERCIAL STANDARD

If acceptance has not previously been filed, this sheet properly filled in, signed, and returned will provide for the recording of your organization as an acceptor of this commercial standard.

Date______________________

Division of Trade Standards,
National Bureau of Standards,
Washington, D. C.

Gentlemen:

Having considered the statements on the reverse side of this sheet, we accept the Commercial Standard CS21-39 as our standard of practice in the

Production [1] Distribution [1] Use [1]

of interchangeable ground-glass joints, stopcocks, and stoppers.

We will assist in securing its general recognition and use, and will cooperate with the standing committee to effect revisions of the standard when necessary.

Signature____
(In ink)

(Kindly typewrite or print the following lines)

Name and title of above officer_______________________________

Company____
(Fill in exactly as it should be listed)

Street address____

City and State____

[1] Please designate which group you represent by drawing lines through the other two. Please file separate acceptances for all subsidiary companies and affiliates which should be listed separately as acceptors. In the case of related interests, trade papers, colleges, etc., desiring to record their general approval, the words "in principle" should be added after the signature.

TO THE ACCEPTOR

The following statements answer the usual questions arising in connection with the acceptance and its significance:

1. *Enforcement.*—Commercial standards are commodity specifications voluntarily established by mutual consent of the industry. They present a common basis of understanding between the producer, distributor, and consumer and should not be confused with any plan of governmental regulation or control. The United States Department of Commerce has no regulatory power in the enforcement of their provisions, but since they represent the will of the industry as a whole, their provisions through usage soon become established as trade customs and are made effective through incorporation into sales contracts by means of labels, invoices, and the like.

2. *The acceptor's responsibility.*—The purpose of commercial standards is to establish for specific commodities nationally recognized grades or consumer criteria and the benefits therefrom will be measurable in direct proportion to their general recognition and actual use. Instances will occur when it may be necessary to deviate from the standard and the signing of an acceptance does not preclude such departures; however, such signature indicates an intention to follow the commercial standard where practicable in the production, distribution, or consumption of the article in question.

3. *The Department's responsibility.*—The major function performed by the Department of Commerce in the voluntary establishment of commercial standards on a Nation-wide basis is fourfold: First, to act as an unbiased coordinator to bring all branches of the industry together for the mutually satisfactory adjustment of trade standards; second, to supply such assistance and advice as past experience with similar programs may suggest; third, to canvass and record the extent of acceptance and adherence to the standard on the part of producers, distributors, and users; and fourth, after acceptance, to publish and promulgate the standard for the information and guidance of buyers and sellers of the commodity.

4. *Announcement and promulgation.*—When the standard has been endorsed by companies representing a satisfactory majority of production, the success of the project is announced. If, however, in the opinion of the standing committee of the industry or the Department of Commerce, the support of any standard is inadequate, the right is reserved to withhold promulgation and publication.

ACCEPTORS

The organizations and individuals listed below have accepted this specification as their standard of practice in the production, distribution, and use of joints, stopcocks, and stoppers. Such endorsement does not signify that they may not find it necessary to deviate from the standard, nor that producers so listed guarantee all of their products to conform with the requirements of this standard. Therefore specific evidence of quality certification should be obtained where required.

ASSOCIATIONS

American Association of Cereal Chemists, Omaha, Nebr.
American College of Surgeons, Chicago, Ill.
American Pharmaceutical Association, Washington, D. C.
Associated Clinics & Hospitals, Inc., Minneapolis, Minn.
Chicago Hospital Council, Chicago, Ill.
National Association of Insecticide & Disinfectant Manufacturers, Inc., New York, N. Y. (In principle.)
Portland Cement Association, Chicago, Ill.
Scientific Apparatus Makers of America, Chicago, Ill.

FIRMS

Abbott Laboratories, North Chicago, Ill.
Ace Glass, Inc., Vineland, N. J.
Agfa Ansco Corporation, Binghamton, N. Y.
Akron, University of, Akron, Ohio
Alabama Polytechnic Institute, Auburn, Ala.
Alabama, University of, University, Ala.
Albany Laboratories, Inc., Albany, N. Y.
Almo Manufacturing Co., Newark, N. J.
American Agricultural Chemical Co., The, New York, N. Y.
American Ceramic Society, Columbus, Ohio. (In principle.)
American Cyanamid and Chemical Corporation, Charlotte, N. C.
American Distilling Co., Inc., The, Pekin, Ill.
American Instrument Co., Silver Spring, Md.
Analytic Laboratory, Jersey City, N. J.
Arizona State Teachers College, Flagstaff, Ariz. (In principle.)
Arizona, University of, Tucson, Ariz.
Armour Institute of Technology, Chicago, Ill.
Atkin & McRae, Los Angeles, Calif. (In principle.)
Atlantic Refining Co., The, Philadelphia, Pa. (In principle.)
Atlas Powder Co., Experimental Laboratory, Tamaqua, Pa.
Baker Chemical Co., J. T., Phillipsburg, N. J.
Baker University, Baldwin City, Kans.
Baptist State Hospital, Little Rock, Ark.
Barrow-Agee Laboratories, Inc., Memphis, Tenn.
Bay Chemical Co., Inc., Weeks, La.
Bell & Beltz, Philadelphia, Pa.
Bellevue Laboratories, Brooklyn, N. Y.
Berge, J. & H., New York, N. Y.
Binney & Smith Co., New York, N. Y.
Borden & Remington Co., Fall River, Mass.
Boston University, Boston, Mass.
Bowser-Morner Testing Laboratories, Dayton, Ohio.
Braun Corporation, Los Angeles, Calif.
Braun-Knecht-Heimann Co., San Francisco, Calif.
Bridgeport Testing Laboratory, Inc., Bridgeport, Conn.
Brooklyn, Polytechnic Institute of, Brooklyn, N. Y. (In principle.)
Brooklyn Union Gas Co., The, New York, N. Y.
Brown & Sharpe Manufacturing Co., Providence, R. I.
Bucknell University, Lewisburg, Pa.
Butler University, Indianapolis, Ind.
C. P. Chemical Solvents, Inc., The, New York, N. Y. (In principle.)
Calco Chemical Co., Inc., Bound Brook, N. J.
California, University of, Chemistry Department, Berkeley, Calif.
California, University of, Office of the Comptroller, Purchasing Department, University Storehouse, Berkeley, Calif.
Calkins Co., The, Los Angeles, Calif.
Callahan & Co., E. J., Baltimore, Md.

Carbide and Carbon Chemicals Corporation, South Charleston, W. Va.
Carr-Lowrey Glass Co., Baltimore, Md. (In principle.)
Case School of Applied Science, Cleveland, Ohio.
Catholic University, Washington, D. C.
Central Scientific Co., Chicago, Ill.
Charlotte Chemical Laboratories, Inc., Charlotte, N. C.
Chemical Manufacturing Corporation, Norfolk, Va. (In principle.)
Chemical Rubber Co., The, Cleveland, Ohio.
Chicago Apparatus Co., Chicago, Ill.
Children's Country Home, Westfield, N. J.
Chiris Co., Antoine, New York, N. Y. (In principle.)
Cincinnati, University of, Chemical Engineering Department, Cincinnati, Ohio.
Clinical Laboratory, The, Newark, N. J.
Colgate University, Hamilton, N. Y.
Colorado School of Mines, Department of Chemistry, Golden, Colo.
Columbia University, Department of Chemical Engineering, New York, N. Y.
Columbia University, Pupin Physics Laboratories, New York, N. Y.
Commercial Solvents Corporation, Terre Haute, Ind.
Commercial Testing and Engineering Co., Chicago, Ill.
Connecticut State Department of Health, Hartford, Conn.
Conray Products Co., Inc., New York, N. Y.
Consolidated Chemical Industries, Inc., Houston, Tex.
Consolidated Edison Co. of New York, Inc., New York, N. Y.
Container Testing Laboratories, Inc., New York, N. Y. (In principle.)
Continental Can Co., Inc., Chicago, Ill.
Conwell & Co., E. L., Philadelphia, Pa. (In principle.)
Cornell University, Department of Chemistry, Ithaca, N. Y.
Corning Glass Works, Corning, N. Y.
Creighton University, Omaha, Nebr. (In principle.)
Crismon & Nichols, Salt Lake City, Utah.
Crowell & Murray, Inc., Cleveland, Ohio.
Curtin & Co., Inc., W. H., Houston, Tex.
Daigger & Co., A., Chicago, Ill.
Dairy Products Laboratory, N. S. Pittsburgh, Pa.
Dallas Laboratories, Dallas, Tex.
Davis, George C., Philadelphia, Pa.
Dawson Chemical Co., Inc., Indianapolis, Ind.
Dayton, University of, Dayton, Ohio. (In principle.)
Denver Fire Clay Co., The, Denver, Colo.
Denver Mud Chemical Co., Kansas City, Mo.
Detroit Testing Laboratory, The, Detroit, Mich.
Detroit, University of, Department of Chemical Engineering, Detroit, Mich.
Dodge Steel Co., Philadelphia, Pa.
Dolbey & Co., Edward P., Philadelphia, Pa.
Dow Chemical Co., The, Midland, Mich.
Drakenfeld & Co., Inc., B. F., New York, N. Y. (In principle.)
Drexel Institute of Technology, Philadelphia, Pa.
Ducas Co., Inc., B. P., Jersey City, N. J.
du Pont de Nemours & Co., Inc., E. I., Charleston, W. Va., Philadelphia, Pa., and Wilmington, Del.
du Pont de Nemours & Co., Inc., E. I., The R. & H. Chemicals Department, Niagara Falls, N. Y.
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Elgin Softener Corporation, Elgin, Ill.
Eppley Laboratory, Inc., The, Newport, R. I. (In principle.)
Erie Laboratory, The, Erie, Pa.
Factory Mutual Laboratories, Boston, Mass.
Feidt & Co., George D., Philadelphia, Pa.
Fisher Scientific Co., Pittsburgh, Pa.
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Florozone Co., Brooklyn, N. Y.
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Frese Corporation, Adolf, Los Angeles, Calif.
Fries & Bros., Inc., Alex, Cincinnati, Ohio.
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George Washington University, The, Washington, D. C. (In principle.)
Georgetown University, Washington, D. C.
Georgia State Highway Department Testing Laboratory, Atlanta, Ga.
Georgia, University of, Athens, Ga.
Gettysburg College, Gettysburg, Pa.
Glascote Products, Inc., Cleveland, Ohio.
Gooch Laboratories, Ltd., Geo. W., Los Angeles, Calif.

Good, Inc., James, Philadelphia, Pa.
Goodman-Kleiner Co., Inc., New York, N. Y.
Gray Industrial Laboratories, Newark, N. J.
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Gulf Research and Development Co., Pittsburgh, Pa.
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Harvard University, Cambridge, Mass.
Harvard University, Chemical Laboratories of, Cambridge, Mass.
Hawaii, University of, Honolulu, T. H. (In principle.)
Heller Co., G. K., Baltimore, Md.
Hercules Experiment Station, Wilmington, Del.
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Hospital of St. Barnabas and for Women and Children, Newark, N. J.
Hospital Supply Co., The, and Watters Laboratories, Cons., The, New York, N. Y.
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Howard Inspecting and Testing Laboratory, Inc., Newark, N. J.
Howe & French, Inc., Boston, Mass.
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Hunt Co., Robert W., Chicago, Ill.
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Illinois Wesleyan University, Bloomington, Ill. (In principle.)
Indiana University, Bloomington, Ind.
Indianapolis Water Co., Indianapolis, Ind.
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Industrial Testing Laboratory, Kansas City, Mo.
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Johns Hopkins University, Department of Chemistry, Baltimore, Md.
Johnson-Salisbury, Inc., New York, N. Y.
Jordan & Bro., Inc., William E., Brooklyn, N. Y. (In principle.)
Kalamazoo Paraffine Co., Kalamazoo, Mich.
Kansas, University of, Chemistry Department, Lawrence, Kans.
Kauffman-Lattimer Co., The, Columbus, Ohio.
Kawin Co., Charles C., Chicago, Ill.
Kessler Chemical Corporation, The, Philadelphia, Pa.
Kettering Foundation for the Study of Chlorophyll and Photosynthesis, C. F., The, Yellow Springs, Ohio.
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Little, Inc., Arthur D., Cambridge, Mass.
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Maas Chemical Laboratories, A. R., Los Angeles, Calif.
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Marquette University, Milwaukee, Wis.
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Massachusetts State College, Amherst, Mass. (In principle.)
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Merck & Co., Inc., Rahway, N. J. (In principle.)
Meyer & Sons, J., Philadelphia, Pa.

Michael Reese Hospital, Chicago, Ill.
Michigan College of Mining and Technology, Houghton, Mich.
Michigan Department of Health, Lansing, Mich.
Michigan State College, Department of Chemistry, East Lansing, Mich. (In principle.)
Michigan, University of, Ann Arbor, Mich. (In principle.)
Middlebury College, Middlebury, Vt. (In principle.)
Millard-Heath Co., The, St. Louis, Mo.
Miller, Anthony J., Rochester, N. Y.
Mills College, Oakland, Calif. (In principle.)
Milwaukee Glass Works, Inc., Milwaukee, Wis.
Mine and Smelter Supply Co., The, Denver, Colo.
Miner Laboratories, The, Chicago, Ill.
Minnesota, University of, School of Chemistry, Minneapolis, Minn. (In principle.)
Mississippi State College, State College, Miss.
Missouri Clay Testing and Research Laboratories, Missouri School of Mines and Metallurgy, Rolla, Mo.
Missouri State Highway Commission, Materials Laboratory, Jefferson City, Mo.
Monmouth College, Monmouth, Ill. (In principle.)
Monsanto Chemical Co., St. Louis, Mo.
Monsanto Chemical Co., Thomas & Hochwalt Laboratories, Research Division of, Dayton, Ohio.
Motz Engineering Co., Bisbee, Ariz.
Mountain Copper Co., Ltd., The, Martinez, Calif.
National Scientific Corporation, Chicago, Ill.
Natural Products Refining Co., Jersey City, N. J.
Nester Co., Inc., L. G., Millville, N. J.
Nevada, University of, Reno, Nev. (In principle.)
New Mexico State Highway Department, Albuquerque, N. Mex.
New Mexico, University of, Albuquerque, N. Mex.
New York, College of the City of, New York, N. Y. (In principle.)
New York Produce Exchange, Bureau of Chemistry, New York, N. Y.
New York Sugar Trade Laboratory, Inc., The, New York, N. Y.
New York Testing Laboratory, New York, N. Y.
Newark College of Engineering, Newark, N. J.
Niagara Smelting Corporation, Niagara Falls, N. Y.
Nice, Paul S., Denver, Colo.
Norfolk Testing Laboratories, Inc., Norfolk, Va.
North Dakota Agricultural College, Fargo, N. Dak.
Northwestern University, Evanston, Ill.
Norwich University, Northfield, Vt. (In principle.)
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Novocol Chem. Manufacturing Co., Inc., Brooklyn, N. Y.
Nutting Co., The H. C., Cincinnati, Ohio.
O. S. & S. O. Home, Xenia, Ohio. (In principle.)
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Ohio State University, Department of Chemical Engineering, Columbus, Ohio. (In principle.)
Ohio University, Athens, Ohio. (In principle.)
Ohio Wesleyan University, Delaware, Ohio.
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Oklahoma, University of, Norman, Okla
Onyx Oil and Chemical Co., Jersey City, N. J.
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Oregon State College, Corvallis, Oreg.
Oregon State Highway Commission, Salem, Oreg.
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Richards Chemical Works, Inc., The, Jersey City, N. J.
Robertson & Co., John H., Chicago, Ill.
ROC Chemical Concern, Council Bluffs, Iowa.
Rochester, University of, School of Medicine and Dentistry and Strong Memorial Hospital, Rochester, N. Y.
Rohm & Haas Co., Inc., Philadelphia, Pa.
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St. Michael's College, Winooski Park, Vt. (In principle.)
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Scientific Supplies Co., Seattle, Wash.
Seldner & Enequist, Inc., Brooklyn, N. Y.
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Seydel-Woolley & Company (Textile Chemicals), Atlanta, Ga.
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Shell Petroleum Corporation, Wood River, Ill.
Shepherd Chemical Co., The, Norwood, Ohio.
Simons, Inc., Harold L., Long Island City, N. Y.
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Smith, Kline & French Laboratories, Philadelphia, Pa.
Snell, Inc., Foster D., Brooklyn, N. Y.
Solvay Process Co., The, Syracuse, N. Y.
South Dakota State College, Brookings, S. Dak.
Souther Engineering Co., Henry, Hartford, Conn.
Sparhawk Co., The, Sparkill, N. Y.
Special Products Co., Inc., The, Franklin Park, N. J.
Stanford University, Department of Chemistry, Stanford University, Calif.
Starr Manufacturing and Chemical Co., Lima, Ohio.
Stauffer Chemical Co., San Francisco, Calif.
Stetson University, John B., DeLand, Fla.
Stillman & Van Siclen, Inc., New York, N. Y. (In principle.)
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Strasburger & Siegel, Baltimore, Md.
Synthetical Laboratories, The, Chicago, Ill.
Syracuse University, Chemistry Dept., Syracuse, N. Y.
Tamworth Associates, Inc., Needham Heights, Mass.
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Texas Technological College, Department of Architecture and Allied Arts, Lubbock, Tex. (In principle.)
Texas, University of, Austin, Tex.
Textile Chemical Co., Reading, Pa.
Textor Chemical Laboratories, Cleveland, Ohio.
Thomas Co., Arthur H., Philadelphia, Pa.
Thompson & Lichtner Co., Inc., The, Boston, Mass.
Todd Co., A. M., Kalamazoo, Mich.
Trinity College, Hartford, Conn.
Twining Laboratories, The, Fresno, Calif.
Universal Oil Products Co., Riverside Ill.
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Vassar College, Poughkeepsie, N. Y.
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Worcester Polytechnic Institute, Worcester, Mass.
Wrigley, Jr., Wm., Co., Chicago, Ill.
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